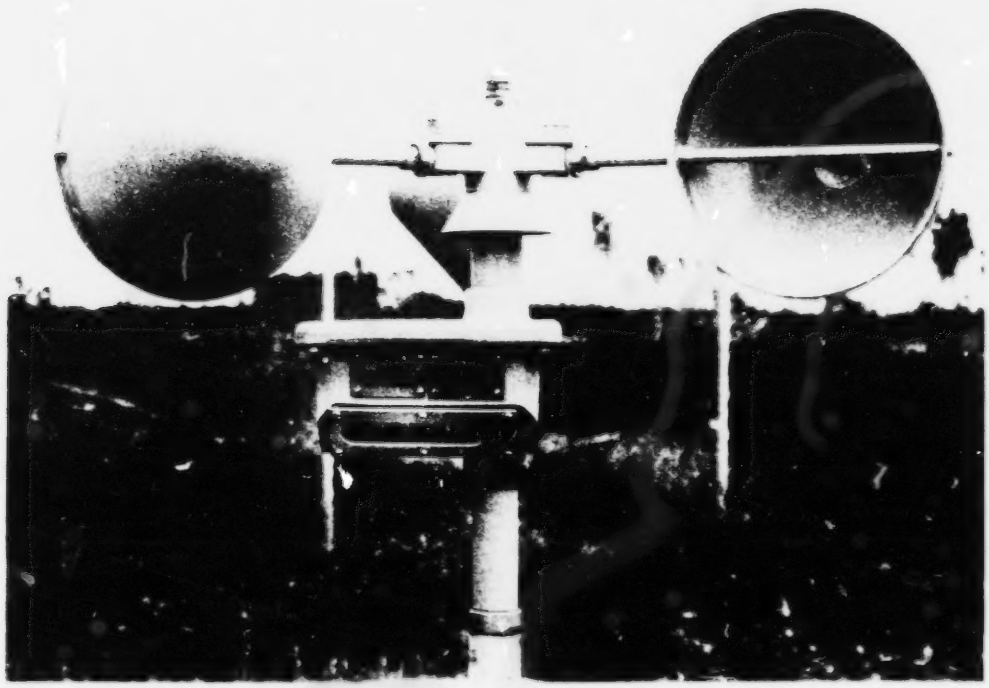
Environment Canada
Environmental Management Service

Correlation between wind speeds at two different heights within a large forest clearing in central Saskatchewan

by Z. Chrosciewicz

Information Report NOR-X-141
September 1975



northern forest research centre
edmonton, alberta

CORRELATION BETWEEN WIND SPEEDS AT TWO DIFFERENT HEIGHTS WITHIN A LARGE FOREST CLEARING IN CENTRAL SASKATCHEWAN

BY

Z. Chrosciewicz

INFORMATION REPORT NOR-X-141
SEPTEMBER 1975

NORTHERN FOREST RESEARCH CENTRE
CANADIAN FORESTRY SERVICE
ENVIRONMENT CANADA
5320-122 STREET
EDMONTON, ALBERTA, CANADA
T6H 3S5

Chrosciewicz, Z. 1975. Correlation between wind speeds at two different heights within a large forest clearing in central Saskatchewan. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alta. Inf. Rep. NOR-X-141.

ABSTRACT

Concurrent midday wind speeds were measured at 4.0 ft (1.2 m) and 32.8 ft (10.0 m) above the ground on a large clear-cut area in central Saskatchewan. This resulted in 301 pairs of wind-speed values which were then used in regression analysis. A strong straight-line relationship (r = 0.97) was found to exist between wind speeds at the two different heights. On this basis, tables were prepared for estimating midday wind speeds in either mph or km/h at 32.8-ft (10.0-m) height from the known wind speeds at 4.0-ft (1.2-m) height.

RESUME

L'auteur mesura les vitesses simultanées du vent de midi à 4.0 pi (1.2 m) et 32.8 pi (10.0 m) au-dessus du sol dans une grande aire coupée à blanc dans le centre de la Saskatchewan. De ceci résultèrent 301 paires de vitesse qui furent analysées par régression. Il en résulta un étroit rapport en ligne droite (r = 0.97) entre les deux vitesses. L'auteur prépara alors des tables pour estimer les vitesses du vent de midi (en milles à l'heure ou en km/h) à 32.8 pi (10.0 m) de hauteur, à partir de la vitesse du vent a 4.0 pi (1.2 m).

TABLE OF CONTENTS

	Page
INTRODUCTION	1
METHODS	1
RESULTS AND DISCUSSION	4
REFERENCES	9

INTRODUCTION

Measurements of wind speeds at the height of 32.8 ft (10.0 m) over level, open terrain are required for use in the new Canadian fire weather tables (Anon. 1970). However, there are situations where wind speeds are measured only at 4.0 ft (1.2 m), which is about the recording height for most other weather observations. Conversion of wind speeds at 4.0 ft (1.2 m) to wind speeds at 32.8 ft (10.0 m), although desirable, is seldom possible because of lack of suitable data. To overcome this difficulty, appropriate wind measurements were taken during two snow-free seasons from May through September in 1970 and 1971, some 15 mi (24 km) north-northeast of Candle Lake, Saskatchewan. The results, including conversion tables, are presented in this paper.

METHODS

The wind observations were made at a weather station on an upland clear-cut area with a flat to gently undulating topography. The immediate clearing was several hundred acres in size within which only a very few, small and widely scattered clumps of trees remained uncut. The radial distances to these clumps from the weather station were nearly 600 ft (183 m) to the nearest one, 900 to 1200 ft (274 to 366 m) to the next three, and at least 2200 ft (671 m) to all others. The ground cover consisted mainly of logging slash and some shrubs not exceeding 3.0 ft (0.9 m) in height. This cover was completely removed from a 100 by 100-ft (30 by 30-m) plot where the station was located.

Two anemometers of the "cup counter" type (Model W 1204/1 by C. F. Casella & Co. Ltd., London, England) were singly mounted at 4.0 ft (1.2 m) and 32.8 ft (10.0 m) above the ground. The instruments totalized their respective wind runs giving readings in statute miles to two decimal places. They could be easily read, directly at 4.0 ft (1.2 m) and through binoculars at 32.8 ft (10.0 m). Wind speeds in mph at both heights were determined from concurrent 15-minute wind runs beginning 7.5 minutes before sun noon. This resulted in 301 pairs of wind-speed values with a range of 2-23 mph (3-37 km/h)[1].

Preliminary plotting of the wind-speed data indicated a straight-line relationship. A regression (Snedecor 1956) between the wind speeds at 4.0-ft (1.2-m) height as variable x and the corresponding wind speeds at 32.8-ft (10.0-m) height as variable y resulted in the equation:

$$[1] \qquad y = 0.0497 + 1.5527x$$

which was subsequently used to compute wind speeds in mph at 32.8-ft (10.0-m) height. The standard error of estimate was 0.91. In addition, a correlation coefficient r was calculated for the existing relationship.

The wind speeds were also computed with the aid of a power-law formula (Geiger 1966) that expressed a curvilinear relationship between wind speeds and heights above the ground. Using x for wind speeds at

---

[1] Additional data included estimated percentages of total cloud cover during all wind-speed measurements.

4.0-ft (1.2-m) height and y for wind speeds at 32.8-ft (10.0-m) height, the equations were:

[2] $$y = b\ 32.8^{a}$$

and

[3] $$x = b\ 4.0^{a}$$

where b was the wind speed at a height of 1 unit, or 1 ft (0.3 m) in this case, and a was an exponent based on actual variation in wind speed with height.

A division of Eq. [2] by Eq. [3] gave:

[4] $$\frac{y}{x} = \frac{32.8^{a}}{4.0^{a}}$$

or

[5] $$\frac{y}{x} = 8.2^{a}$$

which in turn resulted in:

[6] $$y = x8.2^{0.2209}$$

for computing wind speeds in mph at 32.8-ft (10.0-m) height. The exponent a in Eq. [6] was an average value derived from 301 individual

a values, one for each pair of wind speeds measured[2]. The individual values of a were computed using Eq. [5].

The wind speeds as computed by Eqs. [1] and [6] are compared at intervals in Table 1. Tables 2 and 3 show the wind speeds at 32.8-ft (10.0-m) height for a range of wind speeds at 4.0-ft (1.2-m) height. Both these tables were computed in mph using Eq. [6], with subsequent conversions to km/h in Table 3.

RESULTS AND DISCUSSION

The regression revealed that a strong rectilinear relationship existed between the wind speeds at 4.0-ft (1.2-m) height and the wind speeds at 32.8-ft (10.0-m) height[3], with $r = 0.97$. In computing wind speeds at 32.8-ft (10.0-m) height, the power-law Eq. [6] gave somewhat higher estimates than those obtained from the regression Eq. [1]. However, Table 1 shows that the differences were not excessive and that, for all practical purposes, both equations gave adequate estimates.

---

[2] Initially, average a values were determined by broad cloud-cover classes, but the resulting differentiation was too small to have practical application:

Cloud cover %	Pairs of wind speeds	Average a
0 - 80	204	0.2222
81 - 100	97	0.2180
0 - 100	301	0.2209*

* Used in Eq. [6].

[3] This should not be confused with the curvilinear relationship between wind speeds and heights above the ground (see Geiger 1966).

Equation [6] was chosen for computing the values in Tables 2 and 3, mainly because the power-law principle had a well-established theoretical base.

The high degree of correlation suggested that one can be reasonably accurate in estimating wind speeds at 32.8-ft (10.0-m) height from the known wind speeds at 4.0-ft (1.2-m) height. The results, however, should be used with caution until it is known how the a value in Eq. [6] would vary from forest clearing to forest clearing. The wind estimates in Tables 2 and 3 are applicable only to midday on large clearings with flat to nearly flat topography. They are not meant to substitute for adequate wind instrumentation but rather to provide an aid in estimating wind speeds where such instrumentation is lacking.

The results are subject to instrumental error which for the cup-counter anemometers used is less than 1 kn (1.2 mph or 1.9 km/h) at all normal wind speeds above 5 kn (5.8 mph or 9.3 km/h). However, the cups normally begin to rotate at speeds of 1.5-2.0 kn (1.7-2.3 mph or 2.8-3.7 km/h), and up to 5 kn (5.8 mph or 9.3 km/h), the wind readings are affected to a degree by bearing friction (Anon. 1956). Therefore, the accuracy of estimating wind speeds either with the aid of these and similar instruments or by using the conversions in Tables 1 and 2 is probably not greater than 1 or 2 mph (1.6 or 3.2 km/h), depending on wind speeds encountered. Nevertheless such accuracy is often acceptable in rating fire weather over large forest areas.

Table 1. Comparison between midday wind speeds at 32.8 ft (10.0 m) as computed by regression and power-law equations

Wind speed at 4.0 ft (1.2 m)	Wind speed at 32.8 ft (10.0 m)		
	Regression Eq. [1]	Power-law Eq. [6]	Difference
	mph (km/h)		
0.5 (0.8)	0.8 (1.3)	0.8 (1.3)	0.0 (0.0)
5.0 (8.0)	7.8 (12.6)	8.0 (12.9)	0.2 (0.3)
10.0 (16.1)	15.6 (25.1)	15.9 (25.6)	0.3 (0.5)
15.0 (24.1)	23.3 (37.5)	23.9 (38.5)	0.6 (1.0)

Table 2. Midday wind estimates at 32.8 ft from wind at 4.0 ft

Height above ground - ft					
4.0	32.8	4.0	32.8	4.0	32.8
Wind speed - mph					
1.0	1.6	6.0	9.6	11.0	17.5
2.0	3.2	7.0	11.1	12.0	19.1
3.0	4.8	8.0	12.7	13.0	20.7
4.0	6.4	9.0	14.3	14.0	22.3
5.0	8.0	10.0	15.9	15.0	23.9

--- Sample limits.

Table 3. Midday wind estimates at 10.0 m from wind at 1.2 m

Height above ground - m					
1.2	10.0	1.2	10.0	1.2	10.0
Wind speed - km/h					
1.0	1.6	9.0	14.3	17.0	27.1
2.0	3.2	10.0	15.9	18.0	28.7
3.0	4.8	11.0	17.5	19.0	30.2
4.0	6.4	12.0	19.1	20.0	31.8
5.0	8.0	13.0	20.7	21.0	33.4
6.0	9.6	14.0	22.3	22.0	35.0
7.0	11.1	15.0	23.9	23.0	36.6
8.0	12.7	16.0	25.5	24.0	38.2

--- Sample limits.

REFERENCES

ANON. 1956. Handbook of meteorological instruments. Part I. Instruments for surface observations. Air Minist., Meteorol. Office, London, M.O. 577.

ANON. 1970. Canadian forest fire weather index. Dept. Fish For., Can. For. Serv., Ottawa.

GEIGER, R. 1966. The climate near the ground. Harvard Univ. Press, Cambridge, Mass.

SNEDECOR, G. W. 1956. Statistical methods. Iowa State Coll. Press, Ames, Iowa.